DYNAMIC CALL ADMISSION

Field of the Invention

This invention pertains generally to the field of wireless communications and more

5   particularly to systems and methods for dynamic call admission.

Background

The third generation (or "3G") of wireless communication services promises to bring

unity to a fractured worldwide cellular market. 3G systems will permit seamless travel not

10   presently available in the splintered U.S. mobile telephone service. In addition, 3G systems

promise a wide array of high-speed broadband data transmission and processing, including video,

on-board navigation, and Internet access.

One wireless standard designed to support 3G services is cdma2000™, defined by the

ITU in its IMT-2000 vision. Phase one of the cdma2000 standard effort, known as "1xRTT" (i.e.,

15   Radio Transmission Technology), has already been completed and published by the

Telecommunications Industry Association (TIA). 1xRTT refers to cdma2000 implementation

within existing spectrum allocations for cdmaOne – 1.25 MHz carriers. The technical term is

derived from N = 1 (i.e., use of the same 1.25 MHz carrier as in cdmaOne) and the "1x" means

one times 1.25 MHz. 1xRTT is backward compatible with cdmaONE networks, but offers twice

20   the voice capacity, data rates of up to 144 kbps, and overall quality improvements.

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Phase 2 of the cdma 2000 standard (cdma2000-3X) offers even higher capacity than 1X, data rates of up to 2 Mbps, backward compatibility with both 1X and cdmaOne deployments, and other performance enhancements. 3X can also be implemented in existing or new spectrum allocations, but it utilizes a broader band of spectrum. The term 3X refers to N = 3 (i.e. use of

5   three 1.25 MHz carriers). There are currently two implementations of 3X identified in the standard. The Multi-Carrier mode utilizes three 1.25 MHz carriers to deliver 3G services, while the Direct Sequence mode utilizes one 3.75 MHz carrier to deliver the same services. The mode implemented would largely depend on the operator's existing spectrum allocations and usage.

Both 1X and 3X networks provide data services such as remote access of e-mail, mobile

10   Internet browsing, and company information. Both voice and data calls must share the available network resources such as Walsh codes. The capacity of a CDMA network to admit a given voice or data caller is determined very differently than in a TDMA network. In a TDMA network, either a time slot is available for a caller, whether data or voice, or it is not. Thus, a call admission policy in a TDMA system need merely determine how many time slots a caller needs

15   and whether these time slots are available. In contrast to this "binary" capacity, a CDMA network has a much "softer" network capacity – the callers do not occupy discrete time slots but rather share the entire available spectrum with each other simultaneously. Thus, theoretically, so long as a Walsh code is available for use, there are no hard limits on how many calls may occupy the available bandwidth. However, because the Walsh codes have finite levels of cross

20   correlation, as more and more users occupy the bandwidth, unacceptable bit error rates eventually result. Other factors also limit the number of users in a CDMA system. Prior art

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CDMA systems typically divided the total available network resources at a fixed ratio between data and voice callers. This results in certain unavoidable inefficiencies. For example, a data call is typically very bursty, resulting in unpredictable sudden demands on network resources. Apportioning these network resources at a fixed ratio means that, from time to time, the network

5   resources allocated to data callers are unused. These unused network resources could be allocated to voice callers, but must remain unused in such prior art systems, resulting in waste of network resources.

Thus, there is a need in the art for improved call admission policies that dynamically apportion network resources between data and voice users.

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Summary of the Invention

The invention provides in one aspect a method of call admission. Current loads for data and voice calls are estimated. A request for a voice call admission is granted if the total load after voice call admission is less than a maximum permitted power load unless the voice call load

15   after voice call admission exceeds a desired voice call load and insufficient power is available for admitting at least one data call.

A function for estimating a reserved power for accommodating future bursts from existing data calls is also provided. The function is used to predict the total necessary reserved power if a data call request is granted. The request for the data call admission is granted if the

20   load formed by the current load for voice calls and necessary reserved power is less than the maximum permitted power load unless the necessary reserved power after admission exceeds a

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desired data load level and insufficient power is available to admit at least one additional voice call.

Other aspects and advantages of the present invention are disclosed by the following description and figures.

5 **Description of Figures**

The various aspects and features of the present invention may be better understood by examining the following figures:

Figure 1 illustrates typical network architecture for a cdma 2000 wireless system.

Figure 2 illustrates the relationship between the voice call power and the data call power
10 for a prior art call admission policy with a static operating point.

Figure 3 illustrates the relationship between the voice call power and the data call power for a voice call admission policy with a dynamic operating point according to one embodiment of the invention.

Figure 4 illustrates the relationship between the voice call power and the reserved data
15 call power for a data call admission policy with a dynamic operating point according to one embodiment of the invention.

Figure 5 illustrates the relationship between functional entities of a Radio Resource Manager according to one embodiment of the invention.

Figure 6 illustrates the operating region within which voice call admission is granted
20 according to one embodiment of the invention.

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Detailed Description

Turning now to the figures, a typical network architecture 100 for a cdma 2000 wireless system is illustrated in Figure 1. Users at a mobile station such as a laptop computer 110 having a wireless transceiver or a handset 115 may transmit over a reverse radio channel 125 to radio

5 base stations (RBS) 130. Similarly, the radio base stations 130 transmit over a forward radio channel 120 to the users 110 and 115. The forward and reverse radio channels 120 and 125 may carry voice, packet data, or other multi-services. The radio base stations 130 are under the control of a base station controller 135. A mobile switching center 140 connects a public switched telephone network (PSTN) 145 to the base station controller 135 so that voice calls may

10 be placed between users 110 and 115 and users within the PSTN 145. In contrast to voice calls, data flowing to and from the Internet 150 such as packet data may directly enter the base station controller 135 via a packet data core network 155.

The forward and reverse radio channels 120 and 125 each comprise a number of different physical channels that may be divided into two classifications: dedicated and common channels.

15 A dedicated physical channel provides a point to point connection, whereas a common channel provides a point to a multiplicity of points connection. Two important dedicated physical channels are the Fundamental Channel (FCH) and the Supplemental Channel (SCH). The FCH transports dedicated data at data rates of 9.6 Kbps and 14.4 Kbps. In contrast, the SCH is allocated dynamically to meet required higher data rates for packet data services.

20 Unlike a TDMA channel such as in a GSM system, the forward and reverse radio channels 120 and 125 do not have a "hard" binary limit as to the amount of traffic that may be

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carried within each channel. Nevertheless, a call admission policy must be employed to limit the amount of traffic within each channel. In prior art call admission methods, a static operating point or limit on voice and data traffic was established. This static operating point established a maximum level or threshold for the amount of power (denoted as load) for both traffic and data

5   calls. Note that the power for a given voice call will vary in a CDMA system depending upon a user's distance from the base station and the effects of other users within a cell. Thus, an estimate of the voice load or power for a given voice call must be performed periodically during the call's duration to account for this changing power level. Similarly, the load for a data call is even more unpredictable because of the bursty nature of data calls, ranging from a dormant or no

10   load state to a substantial load during a burst period if a high data rate is used. Regardless of how the CDMA system estimates the voice and data loads, a given data or voice call request would not be granted if the resulting total load for either the data or voice calls exceeded the thresholds established by the static operating point. The relationship between the data and voice call loads and the static operating point is illustrated in Figure 2. The static operating point

15   establishes a threshold X1 for the total data call power or load and a threshold Y1 for the total voice call power or load. Suppose the current voice and data loads are as represented by point A, and a request for an additional voice call is made. Suppose further that if this additional voice call is admitted, the total voice call power is increased such that the threshold Y1 is crossed, resulting in an operating point B. Note that the current total data call power level at point B is

20   relatively low so that the existing data calls would not be adversely affected by the admission of this additional voice call. Even if these existing data calls begin "bursting" large amounts of

data, there is a substantial "cushion" of reserve power available to handle these bursts.

Nevertheless, because the threshold Y1 is static, this additional voice call cannot be admitted.

Similarly, suppose that the current voice and data loads are as represented by point C and

a request for an additional data call is made. Suppose further that if this additional data call is

5   admitted, the total data call power is increased such that the threshold X1 is crossed, resulting in

an operating point D. Note that the current total voice call power level at point B is relatively

low so that there is a substantial reserve of power available to admit additional voice calls.

Nevertheless, because the threshold Y1 is static, the operating point D is forbidden, resulting in

the data call admission request being denied. The net effect of the static operating point is that

10   the data and voice call loads are restricted to the cross-hatched area of Figure 2.

In contrast, the present invention provides a dynamic call admission policy that avoids

the inefficiencies introduced by a static operating point by instead having a dynamic operating

point. This dynamic operating point corresponds to desired levels of voice call and data call

power. Figure 3 illustrates the relationship between the voice call power and the data call power

15   for a voice call admission policy with a dynamic operating point. The dynamic operating point is

settable by a user and establishes a desired voice call power and a desired data call power.

Corresponding also to this dynamic operating point is a desired total power level equal to the

sum of the desired voice call power and the desired data call power. Suppose that an estimate of

the current voice and data loads is made, represented by point A. A request for a voice call

20   admission is received that results in voice and data loads after call admission as represented by

point B. The voice call load or power for point B exceeds the desired voice power level

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established by the dynamic operating point. If, however, a sufficient reserve of power is

available to admit at least one data call, the additional voice call is admitted. Suppose further

that after admitting the voice call at point B, the data call load increases, increasing the total call

load to point C. At such a point, there may be insufficient reserve to admit at least one data call

5   if an additional voice call is admitted. Thus, no more voice calls would be admitted. Eventually,

existing voice calls would be completed, resulting in a total call load as represented by point D.

Thus, it may be seen that the total voice call power will asymptotically approach the desired

voice call power when averaged over a sufficient length of time.

Note that an estimate of the current load for data calls will correspond only to those data

10   calls that are presently transmitting bursts of data. There may be other data calls, however, that

still have channel resources allotted to them that are not presently active. These admitted data

calls may become active and begin transmitting bursts of data within a radio channel. Thus, a

data call admission policy should account for all the admitted data calls whether or not they are

presently transmitting bursts in the radio channel. In one embodiment, the present invention

15   accounts for these potentially active data calls by basing the admission of a data call request upon

a "reserved" power that is a function of the presently admitted data calls and the data call seeking

admission. Figure 4 illustrates the relationship between the voice call power and the reserved

data call power for a data call admission policy with a dynamic operating point. The dynamic

operating point defines a desired level or target level for the reserved data call power and the

20   total voice call power. A power maximum equals the sum of the desired reserve data power and

the desired total voice power levels. Suppose a data call admission request is received when the

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total call load based upon the current reserved data call power and the current voice call power

corresponds to point A. Upon admission of the data call, the necessary reserved power for the

data calls corresponds to point B. Although the necessary reserved power exceeds the desired

level defined by the dynamic operating point, the data call will be admitted if sufficient channel

5   resources are available to admit at least one voice call. Suppose that, after admission of the data

call, the current voice call power increases, resulting in a total load as shown by point C. At such

a point, there may no longer be sufficient reserve available to admit a voice call. Thus, no further

data calls would be admitted. Eventually, existing data calls would be completed, resulting in a

total load as shown by point D. As a result of this dynamic data call admission policy, the

10   reserved power for data calls will asymptotically approach the desired level if averaged over a

sufficient period of time.

Note that the reserved power may or may not be sufficient to accommodate all the

admitted data calls should all these calls suddenly begin transmitting bursts in the radio channel.

This raises a separate issue: how to provide channel resources to an already admitted data call if

15   the reserved power is insufficient. An embodiment of the invention provides a scheduler for

scheduling access to channel resources for already admitted data calls that are transitioning from

a dormant to an active state.

Further details of embodiments of the invention are disclosed by the following

discussion. Call admission control in a CDMA network such as illustrated in Figure 1 depends

20   upon the availability of a number of radio resources. A Radio Resource Manager (RRM) is a

collection of functional entities that are responsible for estimating load and residual availability

of the radio resources, and perform resource control, that is, process requests for such resources. The present invention provides a dynamic call admission policy that may use the functional entities of the RRM. This dynamic call admission policy will be described with respect to a cdma2000 network, however, it will be appreciated that the dynamic call admission policy may

5   be implemented in any CDMA network that permits both voice and data calls. Figure 5 illustrates a Radio Resource Manager (RRM) 200 with the following functional entities: A Transmit Power Estimator 205 and a Receive Power Estimator 210 are located within the Radio Base Station (RBS). Within the Base Station Controller (BSC) are a Walsh code allocation 215, a CDMA Channel Air-Interface Voice Equivalent (AVE) monitor 220, a Capacity Monitor 225,

10   a Congestion Control 230, a Call Admission Control 235 and a Radio Channel Control (RCC) 240. Using these functional entities, the RRM 200 will control Walsh functions, frame offsets, forward CDMA channel capacity, reverse CDMA channel capacity, and channel elements. Note that channel elements are, strictly speaking, hardware resources, but are managed by the RRM 200 due to the coupling between Walsh function selection and channel element selection. Such

15   coupling exists because of constraints in the CSM5000.

Load monitors within the RRM 200 include the Transmit Power Estimator 205, Receive Power Estimator 210 and the AVE monitor 220. With information obtained by the load monitors, the BSC keeps updated estimates of the residual availability of its radio resources, as will be described further herein. For those estimators that are distributed at the RBS, load measurements

20   are sent to the BSC either periodically, and/or on-demand, and/or event driven. Further examination of these load monitor are as follows, beginning with the Transmit Power Estimator

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205. Because this denotes transmission from the RBS to a mobile user, it may also be denoted the Forward CDMA Channel Transmit Power Estimator 205.

The Forward CDMA Channel Load Estimator 205 is located at the RBS. The estimator receives periodically the instantaneous transmit power of all traffic channels active on a CDMA channel. The default update period is 20 msec. The total CDMA channel instantaneous power, P_{TX}, is obtained by summing up the individual contributions of a CSM5000 ASIC that are daisy-chained to the CDMA channels. An Application Program Interface (API) in the CSM5000 ASIC retrieves total transmit power measurements filtered over a power control group (1.25 msec) for each of the six CDMA channels it may be connected to. The individual contributions are then filtered by a load estimation function to compute the estimated load, $\hat{P}_{TX}$. The filter may be a single pole IIR filter with different time attack and decay time constants, as described in the following equations:

$$\hat{P}_{TX}(n) = (1-\alpha) \cdot \hat{P}_{TX}(n-1) + \alpha \cdot P_{TX}(n) \,,$$

where

$$\alpha = \begin{cases} \alpha_{UP} & \text{if } P_{TX}(n) \geq \hat{P}_{TX}(n-1) \\ \alpha_{DOWN} & \text{otherwise} \end{cases} .$$

Typically, α_{UP} is larger than α_{DOWN}. Such conservatism is motivated by the fact that it is desirable to react faster to increasing load than it is to decreasing load.

The operation of the Receive Power Estimator 210 is analogous. Because this functional entity is estimating power sent by the mobile units, it may also be denoted the Reverse CDMA Channel Power Estimator 210. The reverse CDMA channel power estimator 210 is located at

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the RBS. The estimator receives periodically the instantaneous digitized received signal strength

indication (RSSI) value. The default update period is 20 msec. The RSSI samples are filtered

using a single pole IIR filter with different time attack and delay values, as described in the

following equations:

5    $\hat{P}_{RX}(n) = (1 - \alpha) \cdot \hat{P}_{RX}(n-1) + \alpha \cdot P_{RX}(n)$,

where

$$\alpha = \begin{cases} \alpha_{UP} & \text{if } P_{RX}(n) \geq \hat{P}_{RX}(n-1) \\ \alpha_{DOWN} & \text{otherwise} \end{cases} .$$

Typically, α_{UP} is larger than α_{DOWN}. Such conservatism is motivated by the fact that it is desirable

to react faster to increasing load than it is to decreasing load.

10   Having obtained an estimate of the current transmitted power in either the forward or

reverse radio channel, a call admission policy must estimate the current power levels for the data

and voice calls. One way to do so is to establish a power reference that individual voice and data

calls are compared. One such suitable reference is the RC3 channel in the FCH operating at a

1% frame error rate (FER). By convention, if a voice call were operating with these

15   characteristics, it is denoted as a full voice equivalent. Thus, if there are a number N_V of voice

callers and they are all operating RC3, the total voice AVE would be simply equal to N_V.

A load monitor to calculate the voice AVE and data AVE is the CDMA Channel AVE

Monitor 220 that is located at the BSC. There is one instance of such monitor per CDMA

channel. The AVE is the total carried traffic expressed in terms of equivalent voice users. Each

20   dedicated traffic channel is expected to carry a load expressed in AVE, which is a function of the

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channel configuration (spreading factor, channel data rate) and service option in use according to a mapping stored in the AVE table of resource control. An example mapping is given by Table 1. Note that an FCH voice activity factor, which may be assumed equal to 0.48, is accounted for in the computation of the AVE.

5   Consider, however, the calculation of the AVE for a data user. Unlike a voice user, a given data user is bursty so that estimating the contributions from data callers to the total current power level estimation should be based only upon data callers transmitting bursts at the time of the total power estimation. The number of these active data users, N_B, must be distinguished from the total number of admitted data users, N_D, who are currently not transmitting bursts.

10   The forward and reverse link AVE load of a CDMA channel is the sum of the AVE of all active forward and reverse traffic channels, respectively. The contributions to the total AVE of voice users and data users with an allocated SCH are tracked separately. That is,

$$AVE_{TOT} = AVE_{VOICE} + AVE_{DATA} = \sum_{i=1}^{N_V} AVE_i + \sum_{i=1}^{N_B} AVE_i .$$

SCH Rate [Kbps]	Code type	RC	Frame Length [msec]	SCH target FER %	AVE relative to RC3 FCH @ 1% FER
9.6	Conv.	3	20	5	0.85
19.2	Conv.	3	20	5	1.7
38.4	Conv.	3	20	5	3.4
76.8	Conv.	3	20	5	6.8
153.6	Conv.	3	20	5	13.6

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When a traffic channel is in soft or softer handoff, such connection contributes to the total AVE of each cell in the active set. Then, to account for connections in soft/softer handoff, the equation for the total AVE is rewritten as

$$AVE_{TOT} = AVE_{VOICE} + AVE_{DATA} = \sum_{i=1}^{N_V} f(K_i) \cdot AVE_i + \sum_{i=1}^{N_B} f(K_i) \cdot AVE_i \,,$$

5   where K_i represents the active set size of the ith connection, and f(K) is a monotonically decreasing function of K. An aggressive approach would be to set f(K)=1/K, while a conservative approach would be to set f(K)=1 $\forall$ K.

The RCC 240 informs the AVE monitor 220 whenever a voice call, or handoff, is either admitted or released, and whenever a data burst is scheduled for transmission. The AVE monitor 10   220 updates the current load estimate and maintains a running average of the voice and data AVE. Because voice is not bursty, the average AVE for voice, $\overline{AVE}_{VOICE}$, may be easily calculated. However, the filtered AVE for data, $\overline{AVE}_{DATA}$, may be computed as

$$\overline{AVE}(n) = \frac{1}{T} \cdot \int_{n \cdot T_S - T}^{n \cdot T_S} \sum_{i=1}^{N_B(t)} f(K_i) \cdot AVE_i \cdot dt \,,$$

where T is filter averaging window and T_S is the update rate. Other types of filters may be used 15   so long as they account for the contributions from the active data users.

The admission control entity 235 must have an estimate of the total forward CDMA channel load caused by active data users that are transmitting a data burst over the SCH channel. This may be accomplished using the current AVE levels for the data and voice calls and the current estimated transmitted power in the following fashion. Let P_{VOICE} and P_{DATA} be the

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aggregate instantaneous transmit power of voice and data users, respectively. Then, from the AVE calculations the following approximation may be made:

$$P_{TX} = P_{VOICE} + P_{DATA} \cong \left(AVE_{VOICE} + AVE_{DATA}\right) \cdot P_{REF},$$

where P_{REF} is the transmit power of a voice user (allocated a RC3 FCH @ 1% FER), which is taken as a reference by convention. Using now the filtered estimates of the AVE and total transmit power, it follows that

$$\hat{P}_{VOICE} \cong \frac{\hat{P}_{TX}}{1 + \dfrac{\overline{AVE}_{DATA}}{\overline{AVE}_{VOICE}}} ; \text{ and}$$

$$\hat{P}_{DATA} \cong \frac{\hat{P}_{TX}}{1 + \dfrac{\overline{AVE}_{VOICE}}{\overline{AVE}_{DATA}}} = \hat{P}_{TX} - \hat{P}_{VOICE}.$$

Note that the transmit power estimation filter time constant used by the Forward CDMA Channel Load Estimator 205 must be set equal to one half of the AVE filter averaging window used by the AVE monitor 220 for the filters to be equivalent in terms of variance reduction.

Based upon these calculated powers for voice and data callers, call admission control of the present invention allows for dynamic allocation of resources between the voice and data users. Although an operating point is set in order to determine the percentile of resources that are to be used by voice and data applications, the resources are allocated in a dynamic manner. This means that in absence of data users, for example, the resources can be utilized by voice users and vice versa. The call admission algorithm of the present invention is designed in such a way that in the presence of a predicted mix of data and voice users, the system will operate at the target operating point. The operating point is settable by the operator. These percentiles will be

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translated to the corresponding values for the transmit power and two subsets of the Walsh code

space for voice and data users. Voice call admission will be discussed first.

In the following algorithm for voice call admission, $\hat{P}_{VOICE}$ is total current transmit power

per CDMA channel for voice users, N_V represents the number of active voice users at the time of

5   admission. In the following, the expected transmit power of the incoming voice user is equal to

the average transmit power per voice user weighted by the new user AVE, AVE_{NEW_USER}. That is,

$$AVE_{NEW\_USER} \cdot \hat{P}_{VOICE} / \overline{AVE}_{VOICE} .$$

Such an estimate of the expected transmit power of the incoming voice user is more

reliable than one based on the initial transmit power as estimated by the forward link open loop

10   power control function. A good estimate predicts the long term expected power consumption,

which, in the case of mobile users, has little correlation with the initial transmit power.

The algorithm first checks whether by granting access to the new voice user the total

power for voice users is going to be larger than the desired operating point or not. If it is going

to be larger, it admits the voice call if and only if there are going to be enough residual resources

15   to allow admission of one or more data calls. Note that the level of necessary residual resources

sufficient to allow admission of one or more data calls is a parameter configurable by the user.

In what follows, the residual capacity set aside is indicated with $P_{DATA\_RESERVED}$, and the

maximum allowable total traffic channel power is indicated with P_{MAX}. Then, the algorithm can

be described by the pseudo-code below.

20   IF

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$$\hat{P}_{VOICE} \cdot \left(1 + \frac{AVE_{NEW\_USER}}{\overline{AVE}_{VOICE}}\right) \leq P_{VOICE\_TARGET}$$

AND

$$\hat{P}_{VOICE} \cdot \left(1 + \frac{AVE_{NEW\_USER}}{\overline{AVE}_{VOICE}}\right) + \hat{P}_{DATA} \leq P_{MAX}$$

THEN

5   GRANT ADMISSION

ELSEIF

$$\hat{P}_{VOICE} \cdot \left(1 + \frac{AVE_{NEW\_USER}}{\overline{AVE}_{VOICE}}\right) > P_{VOICE\_TARGET}$$

AND

$$P_{MAX} - \hat{P}_{VOICE} \cdot \left(1 + \frac{AVE_{NEW\_USER}}{\overline{AVE}_{VOICE}}\right) - \hat{P}_{DATA} \leq P_{DATA\_RESERVED}$$

10   AND

$$\hat{P}_{VOICE} \cdot \left(1 + \frac{AVE_{NEW\_USER}}{\overline{AVE}_{VOICE}}\right) + \hat{P}_{DATA} \leq P_{MAX}$$

THEN

GRANT ADMISSION

ELSE

15   DENY ADMISSION

ENDIF

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The resulting operating region within which a voice call admission request is granted is illustrated by the shaded area in Figure 6.

Turning now to data call admission policy, the algorithm verifies availability of resources based on the residual 'reserved' power of data calls rather than the actual power consumed by data calls. This reserved power is a function of the admitted data calls, regardless of whether these admitted data calls are presently transmitting bursts in the radio channel. In one embodiment, the reserved power could simply equal that required by the total AVE of all the admitted data calls. Such a reserved power assures that if all the admitted data calls suddenly begin transmitting bursts, there will be sufficient channel resources to accommodate all the data calls. Note that such a scenario is not typical because of the bursty nature of data calls. Typically, not all the admitted data calls will transmit a burst in the radio channel at any given time. Thus, a more aggressive approach is to reserve less power than that required by the total AVE of the admitted data calls. In one embodiment of such an aggressive approach, the reserved power is a step function of the total AVE of the data calls that have been admitted in the cell, N_D, and have been allocated a dedicated channel (i.e., non-dormant data calls) but that may or may not be transmitting a data burst on the SCH. That is, $N_D \geq N_B$. The reserved power as a function of the total data AVE is tabulated in Table 1. Note that the reserved power is smaller than the total AVE, the assumption being that multiple users share the same SCH and therefore the same amount of power and resources.

In embodiments of the invention that use a reserved power less than the total AVE of the admitted data calls, it is conceivable that an admitted data caller will seek to transmit a burst but

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there will be insufficient reserved power and channel resources available to accommodate the

burst. A number of scheduler designs will be discussed herein for such an embodiment of the

invention.

The mapping between total data AVE and reserved power depends on the scheduler

5   design, and on the tolerable outage probability. If, however, the use of a scheduler is to be

avoided, the reserved power would be equal to the total AVE of the data users that have been

granted admission, regardless of the fact that they may or may not be transmitting a data burst on

the SCH.

10   Table 1 Reserved power for data calls

Total AVE of admitted data calls, $\sum_{i}^{N_D} AVE_i$	Reserved data AVE power, $f\left(\sum_{i}^{N_D} AVE_i\right)$
≤ 0.4	0.4
$(0.4, 1.6]$	0.8
$(1.6, 3.2]$	1.6
$(3.2, 6.5]$	3.2
> 6.5	6.5

The data call admission algorithm first checks whether by granting access to the new data

user the total 'reserved' power for data users is going to be larger than the desired operating point

or not. If it is going to be larger, it admits the data call if and only if there are going to be enough

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residual resources to allow admission of one or more voice calls. Note that the level of necessary residual resources sufficient to allow admission of one or more voice calls is a parameter configurable by the user. In what follows, the residual capacity set aside is indicated with $P_{VOICE\_RESERVED}$, and the maximum allowable total traffic channel power is indicated with P_{MAX}.

5   Then, the algorithm can be described by the pseudo-code below.

IF

$$f\left(\sum_{i}^{N_D} AVE_i + AVE_{NEW}\right) \cdot \frac{\hat{P}_{VOICE}}{AVE_{VOICE}} \leq P_{DATA\_TARGET}$$

AND

$$\hat{P}_{VOICE} \cdot \left[1 + f\left(\sum_{i}^{N_D} AVE_i + AVE_{NEW}\right) \cdot \frac{1}{AVE_{VOICE}}\right] \leq P_{MAX}$$

10   THEN

GRANT ADMISSION

ELSEIF

$$f\left(\sum_{i}^{N_D} AVE_i + AVE_{NEW}\right) \cdot \frac{\hat{P}_{VOICE}}{AVE_{VOICE}} > P_{DATA\_TARGET}$$

AND

15    $$P_{MAX} - \hat{P}_{VOICE} \cdot \left[f\left(\sum_{i}^{N_D} AVE_i + AVE_{NEW}\right) \cdot \frac{1}{AVE_{VOICE}}\right] > P_{VOICE\_RESERVED}$$

AND

$$\hat{P}_{VOICE} \cdot \left[1 + f\left(\sum_{i}^{N_D} AVE_i + AVE_{NEW}\right) \cdot \frac{1}{AVE_{VOICE}}\right] \leq P_{MAX}$$

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THEN

GRANT ADMISSION

ELSE

DENY ADMISSION

5   END IF

Note that admission requests corresponding to dormant to active transitions are treated

like a new call.

Turning now to discussion of a scheduler, in one embodiment, after a data user is

admitted, the burst requests from this user is processed and an SCH is assigned to this user if

10   enough resources are available in the reserved SCH resource pool. The burst is denied access to

the supplemental channel if there are not enough resources. The user will back off for a random

period of time and try again for burst transmission. In another scheduler embodiment, the bursts

from different data users are queued and scheduled and transmitted according to their position in

the queue as soon as the resources become available. The position of the burst requests in the

15   queue can be a function of number of things such their time of arrival, the higher priority of the

users in SHO, QoS level and so forth. The buffer levels can be used to determine whether an

SCH should be assigned on top of the FCH. At any given time, the scheduler will assign an SCH

to the user with the highest priority as soon as the resources are available. For each user, the

maximum data rate is negotiated at the time of admission, and a power cap or maximum is

20   considered for each data rate. This could be accomplished in a look-up table. The required

transmit power for the data traffic within the SCH at a certain data rate could be either calculated

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using the FCH transmit power or extracted from the up-link SNR. The scheduler may use this power to calculate the data rate at which a burst can be transmitted. A table look-up can be used by the RRM to calculate the overall SCH transmit power for all the active users. A table in the RBS can contain the corresponding maximum power value for each data connection. The

5 scheduler may then use the minimum of the available power and the corresponding maximum power value to determine the data rate at which the burst can be transmitted. The depth of the buffer is used as one of the factors to determine the requested data rate for each user.

For the first discussed scheduler embodiment, the corresponding AVE for data users would be assigned more conservatively to account for the loss of efficiency due to the lack of the

10 scheduler. Note that the scheduler of the present invention, which results in sharing or scheduling of the reserved power in the SCH channel, avoids the complication of a TDMA type mode of operation and works very naturally with the TCP/IP that resides on top of the MAC layer in a cdma 2000 system.

Although specific examples of the present invention have been shown by way of example

15 in the drawings and are herein described in detail, many modifications may be made to these examples and still be within the scope of the present invention. For example, although the call admission policy has been described with respect to the call loads in the forward channel, call loads in the reverse channel could have been considered as well. Furthermore, the scheduler of the present invention is easily modified to work in call admission policies having a fixed

20 operating point. Thus, the invention is not to be limited to the particular forms or methods

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disclosed, but to the contrary, the invention is to broadly cover all modifications, equivalents, and alternatives encompassed by the scope of the appended claims.

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